

**NPOESS PREPARATORY PROJECT (NPP)**

**RAPID II SATELLITE**

**DELIVERY ORDER**

**ATTACHMENT A**

**STATEMENT OF WORK**

May 31, 2002

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**LIST OF AFFECTED PAGES**

Page No.	Revision	Page No.	Revision	Page No.	Revision
Cover Page	Original	34	Original		
i	CH-02	35	CH-02		
ii	CH-02	36	CH-02		
iii	Original	37	Original		
iv	CH-02				
1	CH-02				
2	Original				
3	Original				
4	Original				
5	Original				
6	CH-02				
7	CH-02				
8	Original				
9	Original				
10	Original				
11	Original				
12	Original				
13	Original				
14	Original				
15	Original				
16	Original				
17	Original				
18	Original				
19	Original				
20	Original				
21	Original				
22	Original				
23	Original				
24	Original				
25	Original				
26	Original				
27	Original				
28	Original				
29	Original				
30	Original				
31	Original				
32	CH-01				
33	CH-02				

EOS 420-CM-04 (4/92)

CH-01

## STATEMENT OF WORK TABLE OF CONTENTS

<b>1.0 Introduction .....</b>	<b>1</b>
<b>2.0 Scope.....</b>	<b>2</b>
<b>3.0 Contract Documentation .....</b>	<b>2</b>
3.1 Applicable Documents .....	2
3.2 Reference Document .....	2
<b>4.0 Work to be Performed by the Contractor.....</b>	<b>2</b>
4.1 System Implementation .....	2
4.1.1 Core System .....	3
4.1.2 Core System Option(s) .....	3
4.1.3 Mission-Specific Modifications .....	3
4.2 Non-Standard Services .....	3
4.2.1 Non-Mission-Specific Non-Standard Services .....	3
4.2.2 Non-Mission Specific Hardware .....	3
4.2.3 NPP Specific Non-Standard Services.....	3
4.2.3.1 Resident Office Services and Facilities .....	3
4.2.3.2 Special Studies: NPP and NPOESS Synergism.....	4
4.2.3.3 Electronic Distribution .....	4
4.2.3.4 Video Conferencing.....	4
4.3 Standard Services .....	4
4.3.1 Program Management .....	4
4.3.1.1 Quality Management System.....	5
4.3.1.2 Quality Assurance Requirements .....	5
4.3.1.3 Documentation.....	5
4.3.1.4 Reviews .....	6
4.3.1.4.1 Satellite Kick Off Meeting Requirements .....	8
4.3.1.4.2 Satellite Baseline Design Review (BDR) Requirements.....	8
4.3.1.4.3 Satellite Critical Design Review (CDR) Requirements.....	9
4.3.1.4.4 Satellite Integration Readiness Review (IRR) Requirements.....	12
4.3.1.4.5 Satellite Pre-Environmental Review (PER) Requirements .....	12
4.3.1.4.6 Satellite Pre-Ship Readiness Review (PSRR) Requirements .....	11
4.3.1.4.7 Satellite Acceptance Review (SAR).....	12
4.3.1.4.8 Monthly Status Review (MSR) Requirements .....	12
4.3.1.4.9 Weekly Status Teleconference .....	13
4.3.1.5 Audits .....	13
4.3.1.6 Government Insight .....	13
4.3.2 Systems Engineering .....	14
4.3.2.1 Requirements Analyses and Allocations .....	14
4.3.2.2 Interface Definition, Verification and Control .....	14
4.3.2.2.1 Instrument Interfaces.....	14
4.3.2.2.2 Satellite/Ground Interface .....	15
4.3.2.2.3 Satellite/Launch Vehicle (LV) Interface .....	16
4.3.2.3 Design and Performance Verification Analyses.....	16
4.3.2.4 Safety.....	16
4.3.3 Spacecraft.....	17
4.3.4 Spacecraft/Satellite Integration and Test.....	18
4.3.4.1 GSE .....	18
4.3.4.2 Integration.....	19
4.3.4.3 Test .....	19
4.3.4.4 Contamination Control .....	20
4.3.4.5 Spacecraft/Satellite Storage .....	20

4.3.4.6	Spacecraft, Satellite and GSE Shipment.....	20	
4.3.5	Launch & Operations .....	20	
4.3.5.1	Launch Support .....	21	
4.3.5.1.1	Mission Integration Support for Launch Services.....	21	
4.3.5.1.2	Analytic and Test Support for Launch Services.....	21	
4.3.5.1.3	Launch Operations .....	21	
4.3.5.2	Flight Operations Interfaces and Support.....	22	
4.3.5.2.1	Ground System Interface Definition .....	22	
4.3.5.2.2	Pre-Launch Testing .....	22	
4.3.5.2.2.1	Spacecraft Element / Space Segment (SS) Verification .....	22	
4.3.5.2.2.2	Mission System Functional Testing .....	23	
4.3.5.2.2.3	NPP Compatibility Testing.....	24	
4.3.5.2.2.4	Mission Readiness Testing.....	26	
4.3.5.2.2.5	NPP Launch Site Testing.....	27	
4.3.5.2.3	Ground Systems Training and Flight Operations Training Support.....	28	
4.3.5.3	On-Orbit Performance Verification.....	28	
4.3.5.4	Support to On-Orbit Operations .....	29	
4.3.5.4.1	Anomaly Resolution/Spacecraft Acceptance .....	29	
4.3.5.4.2	Satellite Database Support.....	29	
4.3.5.4.3	On-Orbit Trending .....	29	
4.3.6	Flight Software.....	29	
4.3.6.1	Software Requirements, Development, Verification, and Testing .....	30	
4.3.6.2	Software Maintenance .....	30	
4.3.6.3	Software Development and Maintenance System .....	30	
4.3.7	Miscellaneous Activities .....	30	
4.3.7.1	Pointing Performance Analysis .....	30	
4.3.7.2	Battery Redundancy .....	31	
4.3.7.3	Instrument Solar Constraints .....	31	
4.3.7.4	Real-time Diagnostic Telemetry .....	31	
4.3.7.5	Space/Ground Diagnostic Telemetry Rate .....	31	
4.3.7.6	Space/Ground Diagnostic Telemetry Coverage .....	31	
4.3.7.7	Autonomous Sun Point.....	31	
4.3.7.8	SMD Data Storage.....	31	
4.3.7.9	MAR Level 2 Parts Exception.....	32	
4.3.7.10	Solar Array Qualification-Board (Q-Board).....	32	
4.3.7.11	Workhorse Batteries .....	32	
4.3.7.12	Payload 1553 Data Bus.....	33	
4.3.7.13	CERES Instrument Accommodation.....	33	
4.4	DO Options .....	33	
4.5	Acronyms .....	35	

## 1.0 Introduction

This Statement of Work (SOW) defines the Contractor's efforts required in support of the NPOESS Preparatory Project (NPP) Mission, which include providing the Spacecraft, integrating the NPP ATMS, VIIRS, CrIS, OMPS and CERES Instruments (provided as Government Furnished Equipment (GFE)), and supporting launch and activation.

CH-02

The NPP Satellite will be launched from Vandenberg Air Force Base (VAFB) on a Government-provided Launch Vehicle (LV). The performance and interface requirements for the NPP Satellite are defined in the NPP Satellite Requirements Specification (SRS). The baseline Launch Readiness Date (LRD) for this DO is no later than (NLT) June 30, 2006, with Instruments delivered to the Contractor as specified in Attachment F: GFE List. The Contractor shall complete the NPP Spacecraft to enable Instrument integration NLT January 31, 2005.

CH-02

The NPP Mission is a joint Program between the National Aeronautics and Space Administration (NASA) and NPOESS Integrated Program Office (IPO). The NPP Satellite will provide NASA with continuation of global change observations by extending the measurement series being initiated with EOS Terra (MODIS) and EOS Aqua (AIRS, AMSU, HSB). The NPP Satellite is also being developed as part of the risk reduction of the NPOESS program. The ATMS, CrIS, VIIRS and OMPS sensors being flown on NPP will be flying on NPOESS and the ground system, which will control the NPP Satellite and process the sensor data will be developed by the NPOESS program. To achieve the NPP risk reduction goals, the Contractor is tasked to create a Lessons Learned document specifically targeted at the design knowledge capture of VIIRS, CrIS, ATMS and OMPS integration, test, and operations engineering data.

CH-02

CH-02

Where "the Government" is indicated as providing a function or interface to the NPP Satellite Contractor, the function or interface may be provided by a Government Contractor, primarily, but not limited to the NPOESS EMD Contractor.

The Contractor shall be responsible for executing any Non-Disclosure Agreements the Contractor deems necessary to enable information sharing among the NPP participating contractors. Other formal agreements, if any, between the Contractor and other NPP participating contractors relevant to this delivery order will be subject to Government review.

The term "TBS" (to be supplied) means that the government will clarify or supply the missing information during the course of the Delivery Order. The term "TBR" (to be resolved) means that the requirement may be reviewed for appropriateness by the contractor or the government and may be changed by the government during the course of the Delivery Order.

## **2.0 Scope**

The Contractor shall furnish all necessary personnel, facilities, services, and materials to design, fabricate, integrate, test, and support launch and activation activities for the Satellite developed under this Delivery Order (DO). This work shall be performed in accordance with the requirements of this document and all attachments to the DO.

In accomplishing the development and delivery of the Satellite, the Contractor shall:

1. Provide the Spacecraft.
2. Receive the Instruments and related Ground Support Equipment (GSE), then integrate them with the Spacecraft and perform Satellite level testing.
3. Provide all Spacecraft/Satellite mechanical and electrical GSE required in addition to the GSE supplied by the Instrument providers.
4. Perform combined Satellite testing, ground system compatibility testing, space segment compatibility testing, and pre-launch end-to-end testing in conjunction with Government personnel.
5. Deliver the integrated Satellite and support equipment to the launch site.
6. Support the LV mission integration process, launch base coordination and safety program, Satellite/LV integration and check out, and launch in Government furnished facilities.
7. Provide engineering and management services during launch, early orbit, and activation of the Satellite until Satellite acceptance (approximately 90 days post-launch).

## **3.0 Contract Documentation**

### **3.1 Applicable Documents**

The documents listed in Attachment I: Applicable Documents apply directly to the performance of the DO. These documents establish detailed specifications, requirements, and interface information necessary for the performance of this DO.

### **3.2 Reference Documents**

The documents listed in Attachment I: Reference Documents are for reference only.

## **4.0 Work to be Performed by the Contractor**

### **4.1 System Implementation**

The effort to produce a specified core system, with the selected options, and the mission-unique modifications required in the DO in accordance with the SRS, shall result in a product called the "Spacecraft". The effort to integrate the Instruments, and qualify the

combined Instruments and Spacecraft in accordance with the SRS and Interface Control Documents (ICDs), shall result in a system called the “Satellite”.

#### **4.1.1 Core System**

The Contractor shall develop, implement, integrate, test, and qualify a Spacecraft ready for Instrument integration. The Contractor shall integrate the Instruments with the core Spacecraft, qualify the resulting Satellite, and provide launch support and operations support, as well as satisfy all requirements of section 4.3 of the SOW. The Spacecraft shall conform to the SRS and ICDs.

#### **4.1.2 Core System Option(s)**

Intentionally left blank.

#### **4.1.3 Mission-Specific Modifications**

In order to meet the requirements defined in the SRS, the Contractor shall modify their Spacecraft (core system), as necessary.

### **4.2 Non-Standard Services**

Intentionally left blank.

#### **4.2.1 Non-Mission-Specific Non-Standard Services**

Intentionally left blank.

#### **4.2.2 Non-Mission Specific Hardware**

Intentionally left blank

#### **4.2.3 NPP Specific Non-Standard Services**

##### **4.2.3.1 Resident Office Services and Facilities**

The Contractor shall provide office services and facilities for three NPP Project Office representatives at the Spacecraft manufacturing facility. These facilities are required to support the NPP Project Office throughout the DO.

The Contractor shall provide workspace accommodations for two personnel from each of the NPP Instrument teams during the period of Satellite Integration and Test (I&T). The accommodations shall be in the vicinity of the Instrument GSE to facilitate their day-to-day activities.

The Contractor shall provide workspace accommodations for three ground system



personnel during the period of Satellite I&T.

#### **4.2.3.2 Special Studies: NPP and NPOESS Synergism**

The NPP mission is a precursor mission for the broader NPOESS Program. The development approach of the NPOESS Program necessitates that requirements will continue to evolve after the NPP DO award and during the life of NPP. Requirements change is anticipated, and thus it will be necessary for the Contractor to provide preliminary assessments of the impacts of these potential NPOESS requirements changes.

The Contractor shall perform special studies/task assignments relating to the development, implementation, characterization, qualification, and operation of the Satellite, as authorized by the Government and in accordance with contract clause I.A.1 - RATES FOR NON-STANDARD SERVICES (modified to include special studies, rates and ordering procedures for the NPP Mission as specified in Attachment H).

#### **4.2.3.3 Electronic Distribution**

To the maximum extent possible, the Contractor shall distribute CDRLs and other NPP documentation to the NPP Project Office electronically.

The Contractor shall provide a web-based, password-protected capability to facilitate the communication of information between the Contractor and the integrated NPP Project Team. Deliverable information generated during the DO shall be placed on this web-site in addition to the formal delivery of these items as specified in the CDRL, Attachment D.

#### **4.2.3.4 Video Conferencing**

The Contractor shall have a video conferencing capability. The Contractor shall conduct videoconferences with the NPP Project Office as requested.

### **4.3 Standard Services**

#### **4.3.1 Program Management**

The Contractor shall provide a program management function that is responsible for the control of all effort described in this DO. The Contractor's Program Management function shall provide to the Government reporting and near real-time insight into program status, as well as technical and programmatic performance of all of the Contractor's responsibilities performed under this DO. Schedule reporting shall be in accordance with the CDRL.

The Contractor shall perform various design, study, trade-off and analysis tasks relating to the development, implementation, characterization and operation of the Satellite as necessary.

The Contractor shall be responsible for the rapid submission/negotiation of all change order proposals as required by this DO. Refer to the CDRL, Engineering Change Proposals, Deviations and Waivers.

The Contractor shall implement appropriate management systems that prevent the improper dissemination of Government-provided competition sensitive and/or proprietary information.

#### **4.3.1.1 Quality Management System**

The Contractor shall maintain and adhere to a Quality Management System compliant to ANSI/ASQ Q9001-2000 or as modified by the Contractor and agreed to by the Government.

#### **4.3.1.2 Quality Assurance Requirements**

The Mission Assurance Requirements (MAR) document defines supplemental requirements that shall apply to the DO. The Contractor shall prepare and provide the following documentation as prescribed by the MAR:

1. Satellite Contamination/Cleanliness Control Plan as described in the CDRL.
2. Non-Conformance Reports as described in the CDRL.
3. GIDEP Alert Responses as described in the CDRL.
4. As-Designed/As-Built Parts, Materials, Processes, and Lubrications Lists as described in the CDRL.
5. Parts Control Plan as described in the CDRL.
6. Material Review Board Decisions on Non-Conformances as described in the CDRL.
7. Failure Modes and Effects Analysis and Critical Items List as described in the CDRL.
8. Probabilistic Risk Assessment as described in the CDRL.
9. Fault Tree Analysis as described in the CDRL.

#### **4.3.1.3 Documentation**

The Contractor shall develop, produce, deliver, and maintain all documentation required by the CDRLs and necessary to implement the DO. All efforts including the performance of tests and analyses not otherwise explicitly stated in other parts of this SOW, but determined jointly by the Contractor and the Government to be mission critical, shall be performed and documented by the Contractor. All documentation, data, and analyses generated for, or applicable to, the effort, whether formal or informal, shall be made available to the Government upon request at the Contractor's facility.

The Contractor shall prepare and provide Engineering Change Proposals (ECPs), deviations and waivers as described in the CDRL.

#### 4.3.1.4 Reviews

The Contractor shall conduct usual and customary internal reviews. Additionally, the Contractor shall provide timely reporting of program status to the Government, including progress toward major program milestones. This shall include discussions on problem areas, and a timely transfer of technical information to the Government. The following program reviews shall be conducted, or supported, to certify Spacecraft and Satellite readiness:

Review	Timeframe	Length (Days)	Location	
Satellite Kick Off Meeting	ARO + 1 month	1	Contractor	
Satellite Baseline Design Review	ARO + 6 months	3	Contractor	CH-02
Satellite Critical Design Review (CDR)	As proposed	4	Contractor	
Satellite Integration Readiness Review (IRR)	Jan. 31, 2005	2	Contractor	CH-02
Satellite Pre-Environmental Review (PER)	As proposed	2	Contractor	
Satellite Pre-Ship Readiness Review (PSRR)	1 wk prior to ship	2	Contractor	
Satellite Acceptance Review (SAR)	10 days prior to Satellite handover	1	GSFC	
Monthly Status Review (MSR)	-----	1	-----	
Weekly Status Teleconference	-----	2 hour	-----	

All of the reviews, with the exception of the Kick Off Meeting, the Monthly Status Reviews and the Weekly Status Teleconferences, shall be chaired by the Government. Each review requires a review data package containing appropriate reference documentation for the review. The minutes and action items that result from these reviews shall be documented by the Contractor and made available to the Government. If any deficiencies are found at the reviews, the Contractor shall be required to develop a corrective action plan for the deficiencies prior to proceeding with the affected program development. At the beginning of each review all action items, collected at the previous review, shall be presented with the corrective action, or resolution, taken.

The GSFC/Code 301/System Review Office Design Review Program Guidelines can be found on-line at <http://arioch.gsfc.nasa.gov/301/html/design.html>

In addition to the above reviews, the Contractor shall, as a minimum, provide support to the following reviews/meetings:

<b>Review/Meeting</b>	<b>Timeframe</b>	<b>Length (Days)</b>	<b>Location</b>
Instrument Interface Meetings (with individual Instruments)	Qrtly starting at ARO thru start of payload integration	2	Instrument provider facilities
Ground System Interface Working Group Meetings	Qrtly starting at ARO thru launch	2	Alternate Contractor and NPOESS EMD contractor
Operations Working Group Meetings	Qrtly starting at ARO thru launch	2	Alternate Contractor and NPOESS EMD contractor
Launch Vehicle Interface Meetings	(TBR)	1 (TBR)	(TBR)
NPOESS EMD Interface Kick-Off Meeting	NPOESS EMD Award + 1 month	1	Contractor
Mission Preliminary Design Review (MPDR)	Nov. '02 (TBD, approx. 3 mos. After NPOESS EMD Award)	2	GSFC
CrIS Critical Design Review	TBD	3	Instrument provider facility
Instrument Pre-Environmental Reviews	TBD	2	Each Instrument provider facility
Instrument Pre-Ship Reviews	TBD	2	Each Instrument provider facility
Mission Critical Design Review (MCDR)	13 mos. ARO	2	GSFC
Mission Operations Review (MOR)	Launch - 15 mo.	2	MMC, Wash., DC area
Operations Readiness Review (ORR)	Launch -5 mo.	2	MMC, Wash., DC area
Post-Ship Functional Verification Review	Prior to move to pad	1	VAFB
Flight Readiness Review (FRR)	Launch - 1 week	1	VAFB
Operational Handover Review (OHR)	Launch + 3 months (TBD)	1	Wash., DC area
OMPS Critical Design Review (CDR)	1 <sup>st</sup> quarter CY03	3	Instrument provider facility

CH-02

The NPOESS Engineering and Manufacturing Development (EMD) contract shall be assumed to be awarded in 9/02. The EMD contractor site location shall be assumed to be in California.

Mission Preliminary Design Review (MPDR): The objective of the MPDR is to demonstrate the NPP mission preliminary design is complete, optimal and meets mission requirements, cost and schedule.

Mission Critical Design Review (MCDR): The objective of the MCDR is to verify the detailed design meets mission requirements and system performance. MCDR assesses the maturity of system and interface designs and the maturity of the system integration and test planning.

Mission Operations Review (MOR): The objective of the MOR is to review the status of the system components, including the ground systems and its operational interfaces with the flight systems.

Flight Readiness Review (FRR): The objective of the FRR is to demonstrate that the System is ready for launch. Ground/space segments must be demonstrated to be ready. Interfaces must be checked and functional. All factors must be addressed in constraints. Open items/waivers must be acceptable.

Operational Readiness Review (ORR): The objective of the ORR is to demonstrate that the deployed System is ready to perform the mission. The deployed System must be demonstrated to meet the mission requirements. The System must be proven ready to transition from the developers to the operators. Plans and procedures must reflect actual performance and operations.

Operational Handover Review (OHR): The objective of the OHR is to review the status of Satellite activation and health/functionality of the Satellite. The OHR assesses the readiness of Satellite operations management to transition from NASA to IPO.

#### **4.3.1.4.1 Satellite Kick Off Meeting Requirements**

The Contractor shall review the plans, schedules, and activities required to meet the delivery order. It shall be based on the information detailed in the Contractor's proposal and updated to reflect any changes since proposal submission; including the results of any contract negotiations.

#### **4.3.1.4.2 Satellite Baseline Design Review (BDR) Requirements**

The Contractor shall conduct a BDR describing the current contractual baseline. The objective of this review is to present the baseline design of the Satellite after award of the delivery order in order to familiarize the GSFC independent review team members with the Satellite design, using the Preliminary Design Review (PDR) presentation materials as updated from the Requests for Action generated during the PDR.

#### 4.3.1.4.3 Satellite Critical Design Review (CDR) Requirements

The CDR shall present a final detailed design using substantially completed drawings, analyses, and breadboard/engineering model evaluation testing to show that the design shall meet the final performance and interface specifications and the required design objectives. Changes required to the design from the BDR shall also be included. Final calculations for mechanical loads, stress, torque margins, thermal performance, radiation design and expected lifetime are to be presented. Final software requirements, software design, and updated system performance estimates shall also be presented. Parts selection, de-rating criteria, and screening results, and the results of the Failure Modes and Effects Analyses (FMEAs), Fault Tree Analyses (FTAs) and Probabilistic Risk Assessments (PRAs) are to be presented.

As a minimum, the CDR shall cover the following items:

- System Budgets including updates to mass, power, alignment budgets or total system performance, command/telemetry, data rate, processor memory, and cpu margins.
- Analysis of the Probability of Success for Controlled Reentry utilizing the current design performed to the subcomponent level.
- Closure of actions from the BDR.
- Changes since BDR.
- Spacecraft/Satellite modes, anomaly detection/autonomous response capability, and compliance with sun avoidance requirements.
- Redundancy management.
- Flight software design.
- Pointing accuracy, knowledge, and system jitter analyses.
- Grounding and fusing definitions.
- Risk management items and mitigation plans.
- Identification of special needs such as purge, cleanliness, sensor and instrument stimuli.
- Instrument accommodations.
- Completed Instrument ICDs.
- Flight software architecture.
- Final implementation plans including engineering models, prototypes, flight units, and spares.
- Engineering model/breadboard test results and design margins.
- Final stress and dynamics design analyses.
- Thermal flight predictions.
- Final attitude control system stability analyses.
- Qualification/Environmental test plans and test flow at box, subsystem and system levels.
- Integration and Test Plans.
- Contamination Control Plan.
- Launch vehicle interfaces.

- Ground System interfaces.
- Satellite Operations concept.
- Preliminary Command and Telemetry Handbook
- Reliability analyses results: FMEA, worst case analyses, FTA, PRA.
- Mechanical and Electrical Ground support equipment.
- Plans for shipping containers, environmental control and mode of transportation.
- Problem areas/Open items.
- Schedules.

#### **4.3.1.4.4 Satellite Integration Readiness Review (IRR) Requirements**

The Contractor shall conduct a Satellite IRR. Successful completion of the IRR shall result in Government concurrence that the Spacecraft performance is adequate for the beginning of the Instrument integration process. All procedures required for integration shall be released or ready for release at the IRR.

As a minimum, the following information shall be presented:

- Results of the latest Spacecraft comprehensive performance test.
- Changes since CDR.
- GSE functionality.
- Resolution plans for all failures, anomalies, and malfunctions encountered during component and system testing.
- Remaining open integration issues and their proposed resolution.
- Readiness to perform Instrument integration (e.g. staffing, facilities, GSE, procedures, resources, etc.).
- Plans to proceed to PER (tests, activities, facilities, resources, schedule, flow).
- I&T software readiness and verification status.
- Final (as performed) verification matrix addressing qualification down to the component level of assembly.
- Flight software development and verification status.
- Risk status.

#### **4.3.1.4.5 Satellite Pre-Environmental Review (PER) Requirements**

The Contractor shall conduct a Satellite PER to review all hardware and software test configurations, test plans, procedures, facilities and responsibilities to ensure that the environmental testing will proceed in a controlled manner and that all the necessary requirements and procedures are documented and understood. The PER shall be considered complete upon satisfactory closeout of PER action items critical to proceeding with testing.

As a minimum, the Contractor shall present the following at the PER:

- The results of the Instrument integration and the status of the Satellite development and test.
- A resolution plan for all failures, anomalies, and malfunctions encountered during the Instruments' integration.
- Status against NPP ICDs and margins.
- Status of Satellite GSE instrumentation and environmental test facilities.
- Review of all environmental test plans and procedures.
- The detailed thermal vacuum and thermal balance test plans showing the Satellite in the chamber, the hot and cold plates and shrouds, substitution radiators as required, test targets, RF coupling, test simulators, QCMs, cold finger, planned test profile, tests performed at the plateaus and transitions, cleaning and outgassing plan with analysis support from the Instrument teams.
- The Satellite phasing (end-to-end polarity) verification plans and status.
- The structural qualification/acceptance plan, showing the final modal analyses and coupled loads analyses results.
- Definition of the predicted test limits for the components of the Spacecraft and Instruments (with analysis support from the Instrument teams) for:
  - Dynamic Testing
  - Thermal-Vacuum/Thermal Balance.
- Verification that the planned test environments adequately demonstrate the Satellite performance requirements without presenting a hazard, and without degrading Satellite performance and lifetime by analysis to compliance with the NPP Specifications and ICDs.
- The plans to proceed to Satellite PSRR (e.g. tests, activities, facilities, staffing, resources, schedule, flow).

#### **4.3.1.4.6 Satellite Pre-Ship Readiness Review (PSRR) Requirements**

The Contractor shall conduct a Satellite PSRR to verify and document that the Satellite, Instruments, operations system, and flight and ground software are performing in accordance with the NPP SRS and ICDs. The Satellite PSRR shall be considered complete upon satisfactory closeout of all Satellite PSRR action items.

As a minimum, the Contractor shall present the following at the Satellite PSRR:

- Results of all the environmental tests, end-to-end tests, and the latest Satellite comprehensive performance test and comparison against requirements.
- A resolution plan for all failures, anomalies, and malfunctions remaining open.
- Flight software verification results.
- Any remaining open issues under the DO and their proposed resolution.
- Shipping plans and documentation status (e.g. shipping lists, manifests, containers, handling, transport, etc.).
- Satellite documentation status (e.g. final configuration lists, trend data, test reports, mass properties, system safety plan, life-limited items, equipment logs, cleanliness certification, and any other necessary documents).



- Receiving point plans - arrival time and place, storage, handling, points-of-contact, mechanical and electrical test plans and procedures.
- Detailed plans of the launch support (e.g. activities, facilities, staffing, resources, schedule, flow).
- Contractor's assessment of the readiness of flight operations procedures.
- Command, Control and Communications Segment (C3S) and Space Network (SN) compatibility RF test results and open issues with plan for closure.
- Overview of mission and launch simulations plans.

#### **4.3.1.4.7 Satellite Acceptance Review (SAR)**

The Contractor shall conduct a one-day SAR no earlier than 10 days prior to Satellite hand over to verify and document that the Satellite and its interfaces are performing in accordance with the NPP SRS and ICDs, and that all other requirements under this DO have been completed. The SAR shall be considered complete upon satisfactory closeout of all critical SAR action items.

As a minimum, the Contractor shall present the following at the SAR:

- Results of on-orbit activities.
- Modifications of flight operations procedures and other documentation.
- Status/update of all configuration managed items.
- Status and resolution plan for all failures, anomalies, and malfunctions.
- Satellite documentation status (e.g., nonconformance reports and the Satellite On-orbit Performance Report).
- Any additional material/data required to support completion of all Contractor proposed final milestone completion criteria.
- Results of final mass and Center of Gravity (CG) tests.
- Assessment of readiness of Operations and Maintenance (O&M) team, procedures, and equipment to assume full operations and support responsibilities.

#### **4.3.1.4.8 Monthly Status Review (MSR) Requirements**

The Contractor shall conduct MSRs to review project status in terms of schedule, technical issues, performance (and margin), manpower, and to identify problem areas and assign action items for their solution. To save time and travel, these meetings should be combined with other reviews, videoconferences, or teleconferences at the discretion of the Government. Minutes of these meetings with a copy of the review hand-outs shall be submitted as the monthly status report.

The Contractor shall present the following information at the MSRs:

- Status of all work being performed including appropriate metrics.
- Detail status of schedule.
- Status of project staffing and any shortages.

- Milestone Monitoring - The Contractor shall report on the status of progress made toward accomplishing each of his major milestones. Each report shall include a listing of major accomplishments and a discussion of any problems associated with each milestone as well as their resolution.
- Status of technical risks.
- Changes to design parameters such as weight, power profile, communications, system performance, etc.
- Resource allocations and margins (telemetry, commands, power, weight, data storage, processor capability, etc.)
- Descriptions and status of technical issues and the resolutions.
- Subcontract technical performance, manpower resources, schedule, and milestone status.
- Performance assurance status including non-conformance reports.

#### **4.3.1.4.9 Weekly Status Teleconference**

The Contractor shall support Weekly Status Teleconferences throughout the DO. A Weekly Status Teleconference is not required during the week that an MSR is held. The Contractor shall address the following topics as a minimum in the teleconferences:

- DO activities, plans, and progress against those plans.
- Review of calendar of upcoming meetings and events.
- Communications and Correspondence.
- Issues and Action Items.

#### **4.3.1.5 Audits**

The Contractor shall support standard Government audit of processes, products, documentation and data in order to provide assurance to the Government that the program is being implemented according to all requirements and specifications.

#### **4.3.1.6 Government Insight**

All Contractor and subcontractor internal data, reviews, audits, meetings and other activities pertinent to the execution of the contract shall be open to Government review/attendance. The Contractor shall provide the Government with reasonable and timely notification, to facilitate Government attendance. Government NPP contractors may also attend these reviews, audits, and meetings at the Government's discretion.

The Contractor shall ensure that all software documentation and code required for the NASA Software Independent Verification and Validation (IV&V) effort is made available to NASA IV&V personnel. Wherever possible, the Contractor shall permit electronic access to the required information. The Contractor shall allow NASA IV&V review and participation before final product delivery to the Government.

#### **4.3.2 Systems Engineering**

The Contractor shall perform the necessary systems engineering required to ensure that the Satellite and related deliverables meet all of the functional performance, interface, and implementation requirements of the DO. The systems engineering effort shall comprise the analyses of technical requirements, allocation of derived system, Spacecraft, ground system interfaces, and lower level requirements, definition and maintenance of interfaces, verification of all defined and derived requirements, risk management, tradeoff analyses, and configuration control. The systems engineering effort shall be coordinated with the NPP Mission systems engineering effort, and shall be ongoing through development and on-orbit activation of the Satellite.

#### **4.3.2.1 Requirements Analyses and Allocations**

The Contractor shall conduct complete analyses of the Satellite requirements that fully establish, define, maintain, and control allocations. An updated index of analyses and allocations shall be maintained by the Contractor and documented in the Satellite Level 4 Specification as described in the CDRL. The results of all analyses shall be made available by the Contractor for Government review at each subsequent major program review.

#### **4.3.2.2 Interface Definition, Verification and Control**

Using the results of the analyses and allocations of technical parameters performed in support of the efforts described in section 4.3.2.1, the Contractor shall specify all interfaces not explicitly defined by Government specifications. These interfaces shall then be defined, documented, verified, and controlled for the duration of the contract, by the Contractor.

A Satellite Performance Verification plan shall be prepared in accordance with the CDRL. External Interfaces, Models, and Analysis shall be documented as described in the CDRL. Telemetry and command requirements shall be documented in accordance with the CDRL.

##### **4.3.2.2.1 Instrument Interfaces**

The Contractor shall perform systems engineering and analysis in support of designing, documenting, and implementing all interfaces between the Spacecraft subsystems and the Instruments, and Spacecraft GSE-to-Instrument GSE. This support shall include the following:

1. Generating and maintaining configuration management of the Spacecraft-Instrument interface control documents in accordance with the CDRL.
2. Addressing Instrument accommodations/status as part of each Spacecraft review.
3. Identifying cognizant engineer(s) responsible for the Spacecraft interface to the Instruments.
4. Providing technical support for interface design, documentation, and verification.

5. Performing mechanical, thermal, power, contamination, radiation shielding, and other analyses as necessary to ensure Spacecraft to Instrument compatibility.
6. Attend key Instrument reviews prior to Instrument deliveries.

Reduced Thermal Math Models (TMM's) of the Instruments will be supplied by the Government for use in designing the Spacecraft-Instrument interfaces. The Contractor shall combine the Instrument models with the analytical models of the Spacecraft to create a system level thermal model of the Satellite. The Contractor shall create a table of Environmental backloads with the Satellite model for distribution to the Instrument teams in order to verify that the Contractor's independent modeling correctly reflects the integration into the Spacecraft's thermal environment. This process is iterative and shall be provided to the Instrument teams one month prior to CDR, PER, and PSR. The Satellite TMM shall be correlated with the test data from two thermal balance points from the thermal vacuum test to an accuracy of  $\pm 3^\circ\text{C}$  and  $\leq 5\%$  error in the energy balance with Satellite boundaries. Deviations greater than either criteria between the pretest predictions and the final Satellite TMM shall be investigated, resolved, and reported. The Satellite TMM shall be used for both the design of the Instrument interfaces with the Spacecraft, and demonstrate compliance with the interface requirements. Additionally the Satellite TMM shall be used to provide temperature predictions through every mission phase and all Satellite modes. Predictions are to be based on credible worst case stacking of parameters in bounding the design, e.g. Beginning of Life (BOL) predictions with cold orbital environments and minimum power dissipations, End of Life (EOL) predictions with hot orbital environments and maximum power dissipations.

In addition, NASTRAN Finite Element Models (FEMs) of each Instrument will be supplied by the Government for use in designing the Satellite. The Contractor shall combine the Instrument FEMs with the Spacecraft FEM to form a combined comprehensive Satellite FEM for launch and on-orbit configurations, and shall provide the Satellite FEM to the Government for coupled load analyses by the LV provider. After completion of the coupled loads analysis, the Government will provide the results of the coupled loads analysis to the Contractor. The Contractor shall provide to the Government the Instrument-related results from the coupled loads analysis. The Government will then provide appropriate information to the Instruments relating to launch loads.

#### **4.3.2.2.2 Satellite/Ground Interface**

The Contractor shall prepare a Space Segment (SS) to C3S (SS-C3S) ICD in accordance with the CDRL. The Contractor shall work closely with Government mission engineers to design a system that meets all of the specified mission requirements.

The Contractor shall perform all analyses and tests required to ensure proper operational compatibility between the Satellite and the Government-provided ground segments. The Contractor shall develop, maintain, and provide all technical and programmatic documentation required to ensure successful operation of the Satellite, including the

requirements outlined in the Satellite and Operations Description Manual and the Flight Activation Operations Plan as described in the CDRL.

#### **4.3.2.2.3 Satellite/Launch Vehicle (LV) Interface**

The Contractor shall participate in the preparation and maintenance of the Satellite-to-LV ICD. The Contractor shall submit LV documentation in accordance with the CDRL. In addition, the Contractor shall participate in the preparation and maintenance of the Satellite-to-LV ICD. The responsibility for writing, maintaining, and gaining approval of this ICD will reside with the Government.

A flight ready mechanical fit check and an electrical interface verification test of the Satellite to the LV interface shall be performed by the Contractor prior to the final flight mate to LV interfaces. The mechanical fit check and electrical interface verification test shall be performed at the Contractor's location prior to shipment to the launch site. The Government (or launch services provider) shall supply a test payload attach fitting which simulates the LV side of the interface.

The Contractor shall provide the analytical models and shall perform all analyses and tests required to ensure proper electrical, mechanical, thermal, and operational compatibility between the Satellite and the Government-provided LV and LV environments. The Government, through the launch service provider, will provide for 2 cycles of Coupled Loads Analysis. The Contractor shall develop, maintain, and provide all technical and programmatic documentation including the Satellite Launch Site Operations and Test Plan and Satellite Launch Site Operations and Test Procedures in accordance with the CDRL.

#### **4.3.2.3 Design and Performance Verification Analyses**

The Contractor shall perform and document all analyses of the data and information from the design, qualification testing, acceptance testing, compatibility testing, on-orbit testing of the Contractor's hardware and software which are required to ensure that the program will meet its specifications and objectives. The Contractor shall acquire trend data to allow the evaluation of all critical functions, and shall analyze these data to demonstrate system integrity throughout the Spacecraft and Satellite test programs.

#### **4.3.2.4 Safety**

The Contractor shall plan and conduct a system safety program for the Satellite that accomplishes the following:

- Provides for the identification and control of hazards to personnel, facilities, support equipment, and flight systems during all stages of project development and integration. The program shall also consider hazards in the flight hardware, software, associated equipment and potential malfunctions in Instrument GSE that may affect the Spacecraft or the LV.

- Satisfies the applicable guidelines, constraints, and requirements stated in the latest version of the EWR 127-1, Eastern and Western Range Safety Requirements.
- Interfaces effectively with the industrial safety requirements of the contract and the Contractor's existing safety program.

The Contractor shall provide Satellite level safety-related documentation as required by the launch site and launch range organizations. The Contractor shall submit the Missile System Prelaunch Safety Package (MSPSP) in accordance with the CDRL. The Contractor shall submit Safety Noncompliance Requests in accordance with the CDRL. The Contractor shall submit Ground Operations Procedures for operations that occur outside the Contractor's facility before launch in accordance with the CDRL.

The Contractor shall submit the Debris Generation Analysis Report in accordance with the CDRL. The report shall address: a) The potential for orbital debris generation in both nominal operation and malfunction conditions, including malfunctions during launch, b) The potential for orbital debris generation due to on-orbit impact with existing space debris (natural or human generated) or other orbiting space systems, c) Post mission disposal of Satellite, d) Survival of reentering Satellite system components after post mission disposal.

#### **4.3.3 Spacecraft**

The Contractor shall produce and verify a Spacecraft that meets all of the requirements, specifications, and interfaces in accordance with the SRS and the ICDs. The design shall be verified in accordance with Section 4.3.5.2.2.1.

Prior to Instrument integration, the Spacecraft shall undergo a comprehensive performance test to demonstrate readiness for Satellite level integration. The Spacecraft shall undergo thermal vacuum testing as part of this comprehensive performance testing.

The Contractor shall provide 3 identical Spacecraft-to-Instrument Interface Simulators (SIISs) for use for interface verification during Instrument development. These simulators shall simulate bi-directional command and telemetry interfaces, including serial and discrete interfaces. The Contractor shall make the SIISs available at each Instrument developer's facility for two test events that will occur nominally 12 months prior to Instrument deliveries, and nominally 6 months prior to Instrument deliveries. The Contractor shall provide 1 week of SIIS operations support and user's documentation for each of these tests.

The Contractor shall develop a Spacecraft Command and Telemetry Simulator, and provide incremental updates to improve its fidelity as the Spacecraft Command and Data Handling subsystem matures, for ground system verification testing.

The Contractor shall develop a Spacecraft Simulator for purposes such as Flight Operations Team (FOT) training, FOT procedure verification, and anomaly resolution.

The Contractor shall develop any Instrument software simulation tools and MMC interface simulations required to verify Spacecraft Simulator interfaces and functionality prior to Spacecraft Simulator delivery.

The Contractor shall support the Government ground system contractor with the integration of Government ground system contractor-provided Instrument simulators with the Spacecraft Simulator, and with integration of the Spacecraft Simulator into the MMC. This activity will occur after delivery of the Spacecraft Simulator.

#### **4.3.4 Spacecraft/Satellite Integration and Test**

The Contractor shall integrate and test all Spacecraft and Instrument interface hardware and software for performance and for Spacecraft and Instrument compatibility at the Satellite level. The Satellite shall be tested with calibrated and maintained GSE and shall be compatibility tested with the ground control system as defined in the DO.

The Contractor shall prepare a Spacecraft and Satellite Integration and Test plan in accordance with the CDRL.

The Contractor shall perform an interface test to verify the Satellite High Rate Data (HRD) output.

The Contractor shall provide the Government two copies of all photographs and video tapes taken during integration, testing, and close-outs in accordance with the CDRL.

##### **4.3.4.1 GSE**

The Contractor shall provide the GSE to integrate, test, and verify the Spacecraft and Satellite.

The Government will deliver the Instruments to the Satellite integration and test site. The Government will also provide the Instrument ground support equipment (IGSE) and software (flight and embedded IGSE) necessary to support testing of the Instruments at the Satellite level. The Contractor shall provide the accommodations for the Instrument electrical and mechanical GSE and Instrument stimuli.

The Contractor shall provide an S/Ku-band roof-top antenna system, compatible with TDRSS, at the Contractor's I&T facility to support Spacecraft, Satellite, System, and operations tests.

##### **4.3.4.2 Integration**

The Contractor shall plan and conduct integration of the Spacecraft and Instruments. The Contractor shall develop integrated Satellite test procedures in conjunction with the Instrument providers. The Contractor shall develop the detailed test requirements in conjunction with the Instrument suppliers as part of interface development and documentation. After Instrument integration, all tests shall be conducted through the

Spacecraft and its associated GSE (i.e., Spacecraft GSE to Spacecraft to Instruments). Real-time monitoring of Instrument command and telemetry shall be made available to Instrument analysts supporting the Satellite system level testing. The Contractor shall provide all Instrument test data to Instrument analysts, in mutually agreed to format and media, after completion of testing.

#### **4.3.4.3 Test**

The Contractor shall plan, manage and execute Spacecraft and Satellite interface and performance verification, system testing, and environmental testing as defined in the DO. The Contractor's integration and test program shall include as a minimum:

1. Electrical interface testing performed prior to integration of any assembly, component or subsystems into the next higher assembly. As a minimum, pin out configuration, impedance, and signal characteristics shall be verified.
2. Performance testing shall be performed immediately prior to and immediately after the environmental test program. Performance testing shall verify, to the maximum extent possible, 100% functionality of all components including redundant systems if applicable. Exceptions shall be coordinated with and approved by the Government.
3. Electromagnetic Compatibility Environmental testing, appropriate for the Spacecraft offered, shall be performed to demonstrate self compatibility of the Spacecraft and payload. Compatibility with the LV and launch site as defined by the applicable specifications for each shall also be demonstrated.
4. Thermal Vacuum Environmental testing, appropriate for the Spacecraft offered, shall be performed to demonstrate that all Spacecraft and payload components function properly in their intended operational environment. Representative thermal balance and orbital power simulation tests shall be run in this environment as well.
5. A set of Environmental tests, as specified in the MAR, to verify Spacecraft /component performance given the expected structural loads, vibroacoustics limits, sine vibration limits, mechanical shock limits, and pressure profile induced during all phases of the NPP mission.
6. At no time shall any test (functional or environmental) expose the payload to environments, signals, or other conditions that exceed the limits specified in the Contractor's Instrument ICDs.
7. An end-to-end test shall be conducted with the Mission Management Center (MMC) to verify Spacecraft compatibility with the ground system hardware and software.
8. The Contractor shall provide complete written justification for each analysis the Contractor chooses to perform in lieu of test.
9. The Contractor shall provide complete written justification for each environmental test the Contractor chooses not to perform.

#### **4.3.4.4 Contamination Control**



The Contractor shall assure appropriate contamination control is maintained throughout all phases of integration and test.

The Contractor shall provide a Satellite Contamination/Cleanliness Control Plan in accordance with the CDRL.

#### **4.3.4.5 Spacecraft/Satellite Storage**

Intentionally left blank.

#### **4.3.4.6 Spacecraft, Satellite and GSE Shipment**

The Contractor shall be responsible for the shipment of the Satellite between the place of manufacture/integration with Instruments and the launch facility. The Contractor shall provide for the shipment of necessary GSE required to support the Spacecraft/Satellite during each phase of test, integration, and launch preparation, including the Instrument GSE. The Contractor shall prepare the Satellite Transportation and Handling Plan in accordance with the CDRL. The Government is responsible for the planning, preparation, and shipment of the Instruments' GSE after launch.

The Contractor shall obtain any necessary shipping permits and hazardous material exemptions, etc. During all shipments the Contractor shall perform monitoring of the shipping and handling environment for all controlled conditions (shock, temperature, air cleanliness, air and/or nitrogen purge, and humidity) while the Satellite is in the shipping container.

The Contractor shall reassemble, as required, and check out all Contractor GSE after each shipment, verifying that they are all operating within normal specification limits before their use with the Spacecraft/Satellite. The Government will disassemble, reassemble and check out the Instrument GSE.

#### **4.3.5 Launch & Operations**

The Government will provide the LV and the Satellite processing facility(s).

##### **4.3.5.1 Launch Support**

The Contractor shall support launch vehicle interface definition, launch readiness verification, including final check outs, launch rehearsals and flight readiness reviews. The Government, in conjunction with the Contractor, will make the final go/no-go decision for launch.

##### **4.3.5.1.1 Mission Integration Support for Launch Services**

The Contractor shall provide management and engineering support for all Satellite activities associated with the LV/services. These activities include: systems integration,

interface definitions, interface verification, Satellite to LV integration, ground processing facilities and GSE integration/readiness, and launch support effort. The Contractor shall be responsible for assuring that compatible interfaces between hardware and software are defined, coordinating LV interface requirements definitions, and supporting and/or conducting design and safety reviews, Technical Interchange Meetings (TIMs), and working group and ad-hoc meetings. The Contractor shall support all activities related to the development of interface documentation and provide concurrence that all requirements have been satisfactorily implemented by the Government-provided launch services contractor.

#### **4.3.5.1.2 Analytic and Test Support for Launch Services**

The Contractor shall provide management and engineering support for all analytic efforts conducted by the Government-provided launch services contractor necessary for the assessment of LV environments, interfaces, and ground processing on the Spacecraft design. This support includes development of detailed Satellite analytic models analysis of ground processing facility compatibility, compliance with interface safety requirements, and compatibility with LV flight environments and flight design. The Government is responsible for obtaining valid coupled loads analysis results from the launch organization. The Contractor shall compare the results of the coupled loads analysis cycle to the design loads used in Spacecraft structural analyses to confirm that the resulting loads are within the design requirements as specified in the LV ICD. In addition, the Contractor shall support any tests (e.g., fit checks, shock tests) as required to ensure that Satellite requirements are satisfied.

#### **4.3.5.1.3 Launch Operations**

The Contractor shall provide all required integration, safety, and engineering support to process the Satellite through the ground processing facilities, launch facility, and the LV. In addition, this effort shall encompass the Contractor's efforts necessary to support the actual launch, post-launch orbit insertion, perform Satellite initialization, deployments, and preparation for on-orbit performance verification testing. This activity will be under Government direction from launch through separation of the Satellite from the LV.

#### **4.3.5.2 Flight Operations Interfaces and Support**

The Government will provide ground systems for Satellite operations. The Government furnished Mission Management Center (MMC) operations team shall be responsible for executing all on-orbit operations procedures for the NPP Satellite. The Contractor shall support the training and initial operations of the MMC operations team.

##### **4.3.5.2.1 Ground System Interface Definition**

The Contractor shall provide Satellite compatibility with the ground systems as specified in the DO.

The Contractor shall work closely with Government mission engineers to perform communications, command, control and operational requirements trade analyses.

The Contractor shall provide all necessary interfaces to the ground command, control and data system defined in the documents describing the Satellite requirements contained in the DO. This shall include all necessary system documentation, interface control documents, databases and test efforts.

#### **4.3.5.2.2 Pre-Launch Testing**

The Government has identified an incremental verification approach to be documented in the NPP Performance Verification Plan (per CDRL). This incremental approach identifies an element, segment, flight/ground, and mission system verification sequence culminating in readiness for launch. The requirements for this incremental verification approach are delineated in the following subparagraphs.

##### **4.3.5.2.2.1 Spacecraft Element / Space Segment (SS) Verification**

The Contractor shall integrate and verify the Spacecraft and shall integrate the GFE Instruments onto the Spacecraft and verify the Satellite. The verification of the Spacecraft, an element of the SS, shall include functional and performance testing. The Contractor shall complete verification of the Spacecraft as appropriate prior to the beginning of Instrument integration. The Contractor shall perform functional, performance, electrical, electromagnetic, and interface verification of the integrated Satellite as appropriate, prior to initiating environmental testing. The Contractor shall verify the Satellite requirements, as documented in the SRS, using one or more methods (analysis, inspection, demonstration, and/or test) as selected by the Contractor and defined in the Contractor's Spacecraft and Satellite Integration and Test (I&T) Plan.

In addition to test plan definition, the Contractor shall generate all test procedures, success criteria, test tools and resources to conduct the SS verification. The Contractor shall conduct any pre-test set-up as necessary and define the detailed schedule and dependencies for the execution of the identified tests. Satellite test requirements are detailed in the MAR.

The Contractor shall perform all necessary tasks to verify Satellite function and performance of all interfaces, including C3S, Space Network, Global Positioning System, and High Rate Data ground system. The Contractor shall verify Satellite outputs, format and contents, directly with the interfaces and / or with simulator(s) and ground system equipment provided by the Contractor. The Contractor shall schedule and coordinate all resources required to execute the tests to complete the SS I&T Plan.

The Contractor may choose to coordinate and execute C3S interface tests for early confirmation of the data flows, formats, and contents as specified in the C3S-SS interface documentation. The Contractor shall provide the command database to the Government. Inter-segment testing is considered a mission system level test, but shall be scoped in the

Contractor's verification planning. Informal inter-segment testing with the C3S may be performed prior to launch minus 12 months, if mutually agreeable between the Contractor and the Government. Formal compatibility verification with the C3S MMC shall be supported by the Contractor as part of the mission system testing.

The Contractor shall perform a final comprehensive performance test prior to preparation and shipment of the Satellite to the launch site.

#### **4.3.5.2.2.2 Mission System Functional Testing**

The Government functions as the mission system integrator utilizing the various developers as an integrated test team. The Government coordinates the mission system level requirements verification and testing. These tests include functional thread, inter-segment interface, and system performance tests. The Contractor shall support the functional thread tests involving the SS. Those tests are to be documented in the NPP System Integration and Test (SI&T) Plan (TBS). The Contractor shall develop detailed test procedures to support the identified tests as related to the SS. Those tests shall include:

- Mission event planning and scheduling
- Command processing
- Routine contact with ground receive station (simulated)
- Satellite telemetry processing
- Spacecraft flight software change (simulator)

The Contractor shall support the test execution, post-test analysis and any problem identification and resolution as necessary. The Contractor may identify additional mission thread tests to be performed. The Contractor shall support the SI&T working group meetings to facilitate planning, coordination and scheduling of the tests and the system compatibility test discussed in the next subsection. The Contractor shall participate as a member of the NPP integrated test team. Schedules for mission system tests will be mutually agreed to after award of the DO.

#### **4.3.5.2.2.3 NPP Compatibility Testing**

NPP Compatibility Testing is a unique type of NPP mission system test intended to verify that flight and ground aspects are capable of communicating and handling data, commands, and formats throughout the NPP System. A series of functional compatibility tests with increasing capabilities have been identified with test objectives, target test time frames, and expected durations. Such details are expected to be refined following award of the DO and are to be based on mutually agreeable dates with participating organizations.

The Contractor shall support the NPP integrated test team to plan, coordinate and execute the NPP Compatibility Tests (NCTs). The Government will facilitate the test working group sessions in preparation for test execution. The Contractor shall provide detailed test procedures based on the mutually defined test steps to accomplish the test objectives

and shall coordinate with the Government for generation of test procedures related to the MMC. The Contractor shall provide all necessary information, including the command database, command procedures, and expected results from the SS perspective. The Contractor shall support test execution with engineering support personnel in attendance at the MMC. The Contractor will have final approval of the test procedures and will be capable of halting the test should the need arise. The Contractor shall perform any pre-test setup and check out as necessary to ensure readiness of the NCTs. The Contractor shall be responsible for reviewing and approving the procedures to be executed in the MMC for the NCTs.

The NCTs are:

NCT 1 Test		
Test Objectives	Target Time Frame	Brief Description
<ul style="list-style-type: none"> <li>▪ Initial command database validation</li> <li>▪ Telemetry checks</li> <li>▪ Simple commanding</li> </ul>	14 - 18 mo. prior to launch (prior to inst. integration)	This test verifies all interfaces and data flow between Satellite and MMC for command and data systems using Test Networks established and tested as part of preparation for this test. In addition the test validates the command database, verifies simple commanding and conducts telemetry checks.

NCT 1 is anticipated to run within a day, excluding any setup and other system tests. The actual test configuration may include hard-wired communications and may utilize vendor facilities. NCT 1 is expected to run after Spacecraft integration and check out and prior to the start of Instrument integration.

NCT 2 Test		
Test Objective	Target Time Frame	Brief Description
<ul style="list-style-type: none"> <li>▪ All command telemetry rates</li> <li>▪ SSR dump capabilities</li> <li>▪ Selected Instrument Calibration tables</li> <li>▪ Data routing to SDS (secondary)</li> </ul>	10 - 12 mos. Prior to launch	This test verifies command & telemetry data rates, exercises SRR/dump capabilities, S/C memory loads/dumps. This NCT exercises portions of C3S, IDPS, and portions of SDS for level 1 data processing and climate data processing (as available).

NCT 2 is anticipated to run in two days, excluding any setup. The actual test configuration may include simulators while use of the mission management system at the

operational site is planned. NCT 2 shall have a minimum of one Instrument integrated with the Spacecraft.

<b>NCT 3 Test</b>		
<b>Test Objective</b>	<b>Target Time Frame</b>	<b>Brief Description</b>
<ul style="list-style-type: none"> <li>▪ Propagate through ground system</li> <li>– SDS data processing</li> <li>– Data retrieval from SDS</li> <li>▪ All Instrument Calibration tables</li> <li>▪ High rate data (format)</li> <li>- SMD</li> <li>- HRD</li> </ul>	<p>6 - 8 mos. Prior to launch</p>	<p>This test verifies data routing &amp; retrieval to/from C3S to IDPS and forwarded to Centrals, SDS and ADS, processing &amp; processing of CDRs by SDS, as well as archival and retrieval of data records by ADS. The focus of the high rate data activity will be on the interface compatibility of the format. During this test cycle, the routing of previously recorded data through a polar ground station is introduced.</p>

NCT 3 is anticipated to run in three days, excluding any setup. NCT 3 is expected to run at a mutually agreeable time during the environmental test window. All Instruments are expected to be integrated with the Spacecraft. Propagation of science data through the data systems may utilize simulated data sets.

#### 4.3.5.2.2.4 Mission Readiness Testing

Mission readiness testing includes those exercises, simulations, and certification tests used to prepare the operations staff for launch and mission operations. A series of activities and tests support the operations training and procedure writing. A mission Operational Readiness Test (ORT) is used to ensure the hardware, software, operations procedures, and the staff are ready for launch. Activities such as simulations, proficiency exercises, and launch/dress rehearsals are expected to occur following the final NCT and leading up to the Flight Readiness Review (FRR).

The Contractor shall perform as a member of the operations team as they will during launch and activation. The Contractor shall participate in the readiness activities as integrated team members based on agreed-to roles and responsibilities assigned for launch and activation.

<b>NCT 4 (End-to End Test)</b>		
<b>Test Objective</b>	<b>Target Time Frame</b>	<b>Brief Description</b>
<ul style="list-style-type: none"> <li>▪ Spacecraft through C3S to processing and end user data availability</li> <li>▪ Enterprise management verification</li> <li>▪ Mission SIMS</li> <li>▪ Readiness Exercises – subsets</li> <li>▪ High rate data (format with data)</li> <li>- SMD</li> <li>- HRD</li> </ul>	4 - 6 mos. Prior to launch	This test exercises the baseline configuration and provides the Mission Operations staff with an opportunity for refining operating procedures. The high rate data activity will focus on the data content handling / processing.

The End-To-End (ETE) test is intended to verify the system configuration and operations procedures with the operations staff. The ETE is representative of a day-in-the-life operations concept. The ETE is anticipated to run three days, excluding any setup. The Satellite Contractor shall function as a member of the integrated operations team in conjunction with the Government. The Contractor shall support the Government in the preparation of the ETE test plan.

<b>Operations Readiness Exercises (OREs)</b>	
<b>Test Objective</b>	<b>Brief Description</b>
OREs	Exercises performed for training and refinement of operational scenarios and procedures.

The operational readiness exercises are activities used to train the flight operations team in operating the Satellite. The exercises are expected to include nominal and contingency

procedures and may use simulators. The Contractor shall assume that all nominal and contingency procedures shall be exercised at least once during the OREs. The OREs are run throughout the mission readiness window up until launch. These exercises may include routine simulations, proficiency exercises, operator certification (if necessary), and launch/dress rehearsals. From a training standpoint, the operational exercises shall include both space segment and ground induced anomalous situations and failures from which team members will need to demonstrate their ability to recover. The durations of the exercises may vary depending on the exercise purpose. The Contractor shall provide training, procedure updates/comments and hands-on expertise prior to and during the OREs. The Contractor shall support the Government in the preparation of the ORE test plan.

<b>Operational Readiness Test (ORT)</b>	
<b>Test Objective</b>	<b>Brief Description</b>
ORT	Certify H/W, S/W, Operations & procedures

The Operational Readiness Test (ORT) verifies the launch readiness of the hardware, software, operations procedures, and operations personnel. The ORT is expected to be conducted two to three months prior to launch and run approximately two days.

Flight ready end-to-end interface verification of launch configurations shall be conducted using the Satellite or simulator(s) and the ground segments. The ORT shall be performed using the mission operations staff. The Contractor shall support the Government in the preparation of the ORT test plan.

#### **4.3.5.2.2.5 NPP Launch Site Testing**

Following shipment of the Satellite to the launch site, the Satellite will be processed and mated to the LV. The Satellite and LV interface will be verified based on the SS-LSS interface documentation.

The Contractor shall support/perform all tasks necessary to integrate, test, and prepare the Satellite for launch at the launch site. This includes developing Satellite/LV integration test plans, procedures, and services; check out of interfaces with the LV and launch facilities; and end-to-end tests involving the Satellite, LV, and ground system. The Contractor shall support launch site check out, including post-mate telemetry testing of the Satellite communications in the form of loop back tests with the MMC.

Launch Simulations - This effort encompasses the conduct, analyses, and evaluation of pre-launch training and simulations of the launch (through orbit insertion). Two training simulations and two (TBR) launch rehearsals are to be conducted.



#### **4.3.5.2.3 Ground Systems Training and Flight Operations Training Support**

The Government will provide the contractor with Ground Systems training.

The Contractor shall, in coordination with the MMC operations team, train the Satellite operations team for on-orbit initialization, check out, performance verification, and anomaly resolution. The Contractor shall provide the documentation and data required to provide training and logistics support necessary for the training of MMC operations personnel at the Contractor's facility. Any training presentations shall be videotaped and provided to the Government for future training usage within the C3S. The Contractor shall provide a Satellite and Operations Description Manual in accordance with the CDRL and a Flight Activation Operations Plan as described in the CDRL.

#### **4.3.5.3 On-Orbit Performance Verification**

The Contractor, in conjunction with Instrument support, shall perform an on-orbit performance verification program that shall confirm that the Satellite performance is in accordance with the mission requirements, specifications, and interfaces. The NPP Instrument Operations Team(s) will perform the necessary Instrument testing. As a minimum the Contractor shall perform:

1. Satellite On-Orbit Check Out - After the Satellite has reached the operational orbit and deployed/released all appendages/mechanisms, the Contractor, with the support of the Government-provided Flight Operations Team, shall perform a check out to verify the post-launch performance and state-of-health of the Satellite. The Government-provided Flight Operations Team will issue Satellite commands, monitor the Satellite telemetry, support on-orbit anomaly investigations, and acquire historical data for trend analysis. All nominal systems shall be verified for proper function and performance. The check out shall be planned to occur prior to 90 days on-orbit, but may occur later if Spacecraft anomalies are not resolved. The Contractor shall provide their on-orbit check out plan to the Government in accordance with the Satellite Performance Verification Plan as described in the CDRL. The Contractor shall prepare a report that summarizes the on-orbit performance of the Satellite compared to its required performance for the mission after launch. All pertinent issues affecting mission success shall be addressed. The extent of performance explanation required depends on the seriousness of the impacts that any problems identified may have on mission success. The Contractor shall also provide an assessment of the flight operations team's readiness to assume operational control of the Satellite. This report summarizes the Satellite performance on-orbit after launch and check out to determine initial mission success. Government acceptance of the Satellite will occur after the on-orbit check out based upon successful operation of the Satellite as mutually defined and agreed to in the Flight Activation Operations Plan.
2. Satellite/Ground Control and Data Systems Interface Verification - This effort shall be performed by the Contractor, with the support of the Government-

provided Flight Operations Team, after the Satellite on-orbit performance and state-of-health have been confirmed. The purpose of this effort is to verify proper operations of the Satellite to ground system interfaces and to provide the necessary calibrations.

#### **4.3.5.4 Support to On-Orbit Operations**

The Contractor shall support Satellite check out and operations following launch/Satellite separation. System Lead and Subsystem engineering support shall be provided at the MMC on an around-the-clock basis until all Spacecraft subsystems are activated and checked out and the Satellite is in the mission orbit with all Spacecraft subsystems performing nominally; and 12 hours x 7 days per week coverage through Instrument activation (approximately 30 days); and 8 hours x 5 days per week until Satellite acceptance by the Government. The Government will provide Instrument check out and operations support during this time.

##### **4.3.5.4.1 Anomaly Resolution/Spacecraft Acceptance**

The Contractor shall resolve all out-of-specification on-orbit performance issues as assigned to the Contractor by the NPP Project Office. This support shall remain effective until the end of the check out period, or until Satellite acceptance by the Government. The Contractor shall provide any support required to resolve such pre-acceptance Spacecraft anomalies. This includes support of periodic conference calls on the status of anomalies under investigation.

##### **4.3.5.4.2 Satellite Database Support**

The Contractor shall correct all discrepancies discovered in the Satellite databases until the Government accepts delivery of the Satellite.

##### **4.3.5.4.3 On-Orbit Trending**

The Contractor shall develop an on-orbit Satellite engineering trending approach. The Contractor shall identify parameters to trend, including pseudoparameters, and analyze the data with the intent to identify anomalous performance, out-of-family performance, degradation of components, characterize nominal aging effects, and predict EOL, etc. Comparisons shall be made between on-orbit performance and Satellite-level pre-launch test data. This approach shall be documented in the Satellite and Operations Description Manual as described in the CDRL.

#### **4.3.6 Flight Software**

The Contractor shall treat the software component of firmware, which consists of computer programs and data loaded into a class of memory that cannot be dynamically modified by the computer during processing (e.g., programmable read-only memories, programmable logic arrays, digital signal processors, etc.), as software for the purposes

of this SOW.

#### **4.3.6.1 Software Requirements, Development, Verification, and Testing**

The Contractor shall perform all analyses and systems engineering required to allocate (from system and subsystem requirements) and identify software requirements, develop the necessary design specifications for the Spacecraft, and test and all software. Software requirements traceability to system and subsystem requirements shall be provided in a traceability matrix. The Contractor shall also describe the documentation system, source code generation and use, and the methods of maintaining equipment.

Requirements, design, and code walkthroughs/inspections shall be conducted at the Contractor's facility at the appropriate software developmental life-cycle phase to ensure the correctness of the requirements, design, and source code. These walkthroughs/inspections shall be open to Government participation. The coding, debugging, and developer testing efforts, the results of the walk-throughs, and programmer's notes shall be documented and available at the Contractor's facility for Government review.

The Contractor shall provide all the resources necessary to verify and validate all the software developed for the Satellite.

#### **4.3.6.2 Software Maintenance**

The Contractor shall maintain the flight software and documentation to ensure reliability, maintainability and operability, along with the environments, emulators, and test software necessary to develop, modify, and verify these systems until on-orbit acceptance of the Satellite.

#### **4.3.6.3 Software Development and Maintenance System**

Intentionally left blank.

#### **4.3.7 Miscellaneous Activities**

##### **4.3.7.1 Pointing Performance Analysis**

Analysis shall be conducted to assess system pointing performance. For the purpose of demonstrating system specification compliance, structural damping no greater than .5% shall be utilized in the analysis. For the purpose of evaluating system sensitivity, structural damping no greater than .25% shall be utilized in the analysis.

##### **4.3.7.2 Battery Redundancy**

The spacecraft shall have two (2) batteries each capable of supporting the spacecraft independently.

#### **4.3.7.3 Instrument Solar Constraints**

The Satellite shall not violate instrument solar constraints (TBS) as documented in the UIIDs. The satellite shall employ both primary and backup methods for ensuring compliance with these requirements. The primary methods shall be software based and the backup methods shall be hardware based. In addition, the satellite shall meet the solar pointing constraints in all modes and at all times including eclipse exit. The satellite shall employ a method for ensuring that solar constraints are not violated at eclipse exits by using an ADCS magnetic field following technique or some similar technique during eclipse and when in a sun pointing mode.

#### **4.3.7.4 Real-time Diagnostic Telemetry**

The Real-time Housekeeping Telemetry data flow is a larger set of real-time telemetry. It consists of command receipt verification, real-time engineering data from the instruments and satellite including temperature, pressure, voltage and current sensor output. This data flow may be directly from the SS to the C3S or through the SN. The C3S will process the RHT to update the state of health of the Spacecraft and instruments.

#### **4.3.7.5 Space/Ground Diagnostic Telemetry Rate**

The Diagnostic Telemetry data rate shall be 32 Kbps.

#### **4.3.7.6 Space/Ground Diagnostic Telemetry Coverage**

The Diagnostic Telemetry link margin shall be met over a 62 degree half cone angle centered about the positive Z spacecraft axis.

#### **4.3.7.7 Autonomous Sun Point**

In the event of a solar array deployment failure, the -Y axis of the Satellite shall be autonomously pointed toward the sun.

#### **4.3.7.8 SMD Data Storage**

The spacecraft shall have the capability to store up to 10 minutes of instrument data at up to 24 Mbps as Stored Mission Data (SMD). This requirement shall not drive the SSR sizing requirement.

#### 4.3.7.9 MAR Level 2 Parts Exception

The Viceroy GPS Receiver and the Kearfott IRUs non-Level 2 parts shall be allowed for flight use provided each use is thoroughly evaluated for the thermal, mechanical, and radiation implications of the specific application and found to meet mission requirements.

#### 4.3.7.10 Solar Array Qualification-Board (Q-Board)

The Contractor shall develop a solar array Q-Board that is designed, manufactured and assembled to the standards of the NPP flight solar array. The Q-board shall utilize parts, materials, and processes that are identical to that of the flight solar array. This includes solar cells, substrate, coverglass, interconnects, wiring, connector, terminal board, and adhesive. The Q-board will demonstrate the cycle life for a 5-year mission, using the expected power profile and thermal environment. The Q-board shall not exhibit any defect that would question the ability of the flight solar array to meet the mission life requirements.

There shall be a minimum of 26,000 hot/cold cycles (5 year mission life) over the predicted flight temperature range of -75C to +80C.

The Q-board will be tested at both 28C and at the predicted hot temperature of the array. The testing includes pre-thermal-cycling baseline performance testing, and performance testing at specific cycle breaks. Each circuit on the Q-board is to be tested using the large area pulsed solar simulator (LAPSS). In addition, visual inspection is to be performed at each cycle break to identify any defects, such as cracks, which may be evident.

The contractor shall use a large area pulsed solar simulator (LAPSS) to determine the current-voltage (I-V) characteristics of each qualification and flight panel. The solar simulator shall produce AM0±5% solar intensity at the plane of the panel under test.

The Q-board will have a total 60 cells, configured into strings in accordance with the flight design.

Test data at each of the cycle breaks shall be provided to the NPP Project.

#### 4.3.7.11 Workhorse Batteries

The Contractor shall provide two workhorse batteries for use during Spacecraft and Satellite I&T. The workhorse batteries are to be built and tested to all flight battery requirements. The storage and handling of the workhorse batteries shall be in accordance with all flight procedures and requirements to enable them to be utilized as flight spare batteries.

CH-01

**4.3.7.12 Payload 1553 Data Bus**

CH-01

The Spacecraft design shall incorporate an independent data bus to support all payloads, up to a cumulative bandwidth of 260 Kbps, that require a 1553 compatible bus interface.

**4.3.7.13 CERES Instrument Accommodation**

CH-02

The NPP Spacecraft shall accommodate the CERES Instrument interfaces as GFE'd and as defined in the CERES Instrument specifications cited specified in Attachment I.

**4.4 DO Options****Option-1 Anomaly resolution support after Satellite Acceptance**

The Contractor shall perform task assignments relating to the analysis and resolution of on-orbit Satellite anomalies, as authorized by the Government and in accordance with contract clause I.A.1 - RATES FOR NON-STANDARD SERVICES (modified to include special studies, rates and ordering procedures for the NPP Mission as specified in Attachment H).

**Option-2 90 day Instrument delivery delay with concurrent 90 day Launch delay option (may invoke up to 6 consecutive times)**

The Contractor shall accommodate a 90 calendar day slip in the delivery schedule for any or all Instruments as indicated in the GFE List, Attachment F, with a concurrent 90 calendar day launch delay. This option will be invoked with at least 60 calendar days' notice prior to the Instruments delivery dates on the DO (See GFE List, Attachment F).

**Option-3 12 months of flight software maintenance including documentation (may invoke up to 5 times)**

The Contractor shall maintain the flight software and documentation to ensure reliability, maintainability and operability, along with the environments, emulators, and test software necessary to develop and verify these systems. This option will be invoked with at least 90 calendar days' notice prior to launch or each subsequent option period.

**Option-4 12 months of Spacecraft Simulator maintenance including documentation (may invoke up to 5 times)**

The Contractor shall maintain the Spacecraft Simulator and documentation to ensure reliability, maintainability and operability, along with the environments, emulators, and test software necessary to develop and verify these systems. This option will be invoked with at least 90 calendar days' notice prior to launch or each subsequent option period.

**Option-5 Deletion Of Ku-Band SMD Downlink**

The Contractor shall provide a price credit for the deletion of the Ku-band SMD downlink capability. The exercise date of this option will be no later than January 1, 2003. The price shall reflect all savings resulting from deletion of the Ku-band capability as of the option date, and shall include any relevant subcontract termination costs, Spacecraft redesign costs, etc., which would result from exercise of the option.

**Option-6 Spare Command and Data Handling Hardware**

The Contractor shall fabricate and test a fully redundant spare set of flight-qualified and fully functional Spacecraft command and data handling equipment hardware. This redundant spare set shall encompass command and data handling hardware, high rate science data interface hardware, and data storage hardware. **The exercise date shall be no later than September 2, 2002.** Delivery to the Government shall be at SAR.

Mod 1

## 4.5 Acronyms

ADS	Archive Data Segment
AIRS	Atmospheric Infrared Sounder
AMSU	Advanced Microwave Sounding Unit
ARO	After Receipt of Order
ATMS	Advanced Technology Microwave Sounder
BDR	Baseline Design Review
BOL	Beginning of Life
C3S	Command, Control and Communications
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CERES	Clouds and the Earth's Radiant Energy System
CG	Center of Gravity
CPU	Central Processing Unit
CrIS	Cross-track Infrared Sounder
DID	Data Item Description
DO	Delivery Order
EMD	Engineering and Manufacturing Development
ECP	Engineering Change Proposal
EOL	End of Life
EOS	Earth Observing System
ETE	End to End
EWR	Eastern and Western Range
FEM	Finite Element Model
FMEA	Failure Modes and Effects Analysis
FOT	Flight Operations Team
FRR	Flight Readiness Review
FTA	Fault Tree Analysis
GFE	Government Furnished Equipment
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HRD	High Rate Data
HSB	Humidity Sounder for Brazil
H/W	Hardware
ICD	Interface Control Document
IDPS	Interface Data Processing Segment
IGSE	Instrument Ground Support Equipment

| CH-02



I&T	Integration and Test
IPO	Integrated Program Office
IRR	Integration Readiness Review
IV&V	Independent Verification and Validation
L-	Launch Minus
LV	Launch Vehicle
MAR	Mission Assurance Requirements
MCDR	Mission Critical Design Review
MMC	Mission Management Center
MODIS	Moderate Resolution Imaging Spectroradiometer
MOR	Mission Operations Review
MPDR	Mission Preliminary Design Review
MSPSP	Missile System Prelaunch Safety Package
MSR	Monthly Status Review
NASA	National Aeronautics and Space Administration
NASTRAN	NASA Structural Analysis
NCT	NPP Compatibility Test
NLT	No Later Than
NPOESS	National Polar-Orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project
O&M	Operations and Maintenance
OHR	Operational Handover Review
OMPS	Ozone Mapping and Profiler Suite
ORE	Operations Readiness Exercises
ORR	Operations Readiness Review
ORT	Operational Readiness Test
PDR	Preliminary Design Review
PER	Pre-Environmental Review
PRA	Probabilistic Risk Assessment
PSRR	Pre-Ship Readiness Review
RF	Radio Frequency
RFO	Request for Offer
RSDO	Rapid Spacecraft Development Office
RSA	Rapid Spacecraft Acquisition
Qtrly	Quarterly
QCM	Quartz Crystal Microbalance
SAR	Satellite Acceptance Review
SIIS	Spacecraft-to-Instrument Interface Simulator

| CH-02

SIM	Simulation
SI&T	System Integration and Test
SN	Space Network
SOW	Statement of Work
SRS	Satellite Requirements Specification
SS	Space Segment
S/W	Software
TBD	To Be Determined
TBS	To Be Supplied
TDRSS	Tracking and Delay Relay Satellite System
TIM	Technical Interchange Meeting
TMM	Thermal Math Model
VAFB	Vandenberg Air Force Base
VIIRS	Visible Infrared Imaging Radiometer Suite